
Designing Blo-nut: Design Principles, Choreography and Otherness in an Expressive Social Robot

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Abstract

Both a provocative artistic object and research artefact, *Blo-nut* is part of a project where we explore novel robotic behaviour away from the mimicry of complex human expressions more commonly associated with robotic form and movement. In this pictorial we start by outlining our underlining design principles for the design process and use images to describe the making, real-time GUI and the 'choreographic sketching' of Blonut's movement characteristics. Finally, we argue for embracing novel and provoking 'otherness' in form and material when exploring interaction and communication with social robots.

Authors Keywords

Expression; Non-anthropomorphic; Otherness; Choreography; Soft Robotics; Playfulness;

ACM Classification Keywords

H.5.m

Introduction.

Blo-nut is a prototype designed to explore human interpretation of an animated and abstract artefact intended to exhibit provoking and life-like behaviours. The role of the Blo-nut along with the preceding and continued making processes is two fold. Firstly to demonstrate motions that are afforded by embracing otherness* in a design process. Secondly, to help us get to grips with and articulate

**An aesthetic category broadly used to describe robotic forms that are neither anthropomorphic or zoomorphic in their outward form [5].*

the aesthetic qualities and interaction potential of this expressive 'otherness'.

How it works

Construction-wise, Blo-nut is a donut-like, soft robotic artefact with three independently inflating segments, actuated by blowing air into the pockets between 3D printed inserts and a moulded soft silicone skin. The interface we use for programming Blo-nut's movements was designed using Max/MSP, a software more widely used for digital music manipulation. The result is an editable GUI appropriate for real-time manipulation of Blo-nut's movements over a 64 beat sequence. Crucially, this interface affords us an opportunity to work with experts chosen for their literacy in body language, movement and expression, not necessarily their knowledge of robotics and programming. This meant an opportunity to invite dancers and other performance artists to compose their own movement sequences in collaborative sessions we called 'choreographic sketching'.

Background and Process

Our process builds on work previously highlighted as having the potential to expand the design space for soft robotics. Namely by using combinations of abstract form, material and movement in order to design provoking and emotive performing objects [4]. In order to develop these ideas further, we took a playful and hands on approach with the aim of creating an object dexterous enough to afford a wide range of expressive movements, and robust enough to stand up to the naturally physical reactions and interactions we hoped to provoke.

The process outlined in this pictorial is based on our three emerging design principles and underpinned by an in house knowledge of silicone and latex moulding, CAD

modelling practices and digital music programming taken from Industrial Design and Interaction Design.

Emerging Design Principles for Expressive Soft Robots

In order to guide the reader through the design process presented in this pictorial these principles will be referenced continuously as annotations in the grey column on each page.

Principle 1 – Juxtaposition

A surprising and playful juxtaposition of form and expected movement. We are interested in exploring how this can be achieved through life-like movement of abstract and non-human form.

Principle 2 – Elasticity

A combination of form, material and construction that allows for the maximum possible expansion/ transformation of neutral shape for maximum temporal dexterity. For example, aiming for greatest potential variations in transformation speed, tempo etc.

Principle 3 – Robustness

This work forms in part, a critique of common robotic aesthetics, however it also serves as demonstrable alternative. If these alternative social robots can be robust in their form, they can be imagined as feasible for future physical robotic interactions. We therefore aim for a robust and handleable form that lends itself to physical interaction is crucial.

**INSPIRATION -
PERFORMING OBJECTS**

Elastic Interactions [3] consisted of a variety of inflating and deflating latex shapes, contrasting a skin-like texture with abstract shapes and fine brass fittings, lures and silicone pipes. Each shape had its own character and movement. The objects' performances provoked a variety of reactions from the visitors, ranging from outright disgust to joy and feelings of compassion for the 'creatures'. These objects along with other 'performing objects' works by the author have led to the emerging design principles detailed in this pictorial.



DEFINING A STARTING SHAPE

P1- Juxtaposition

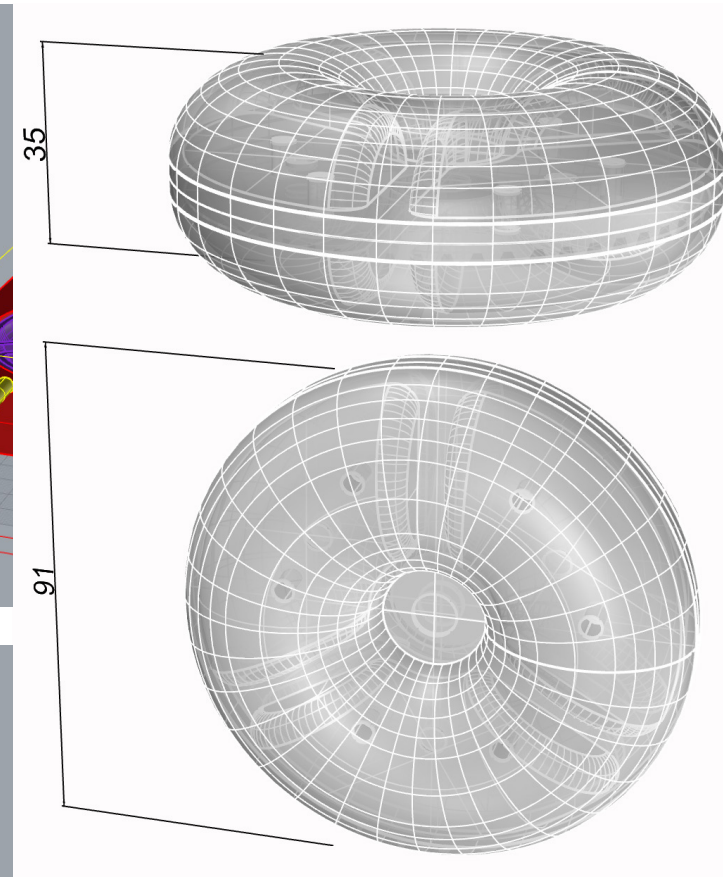
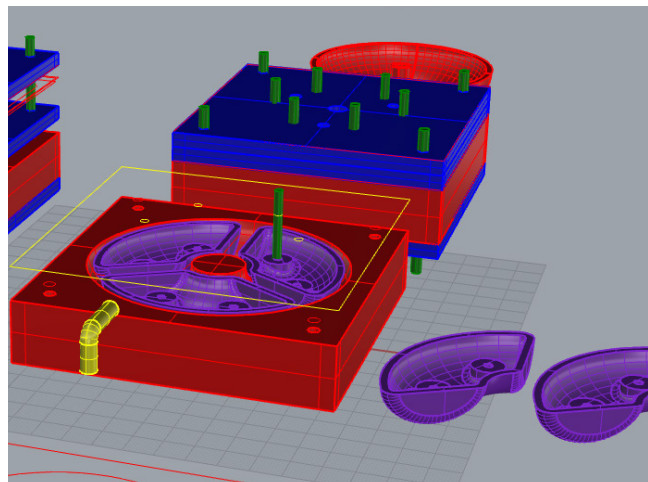
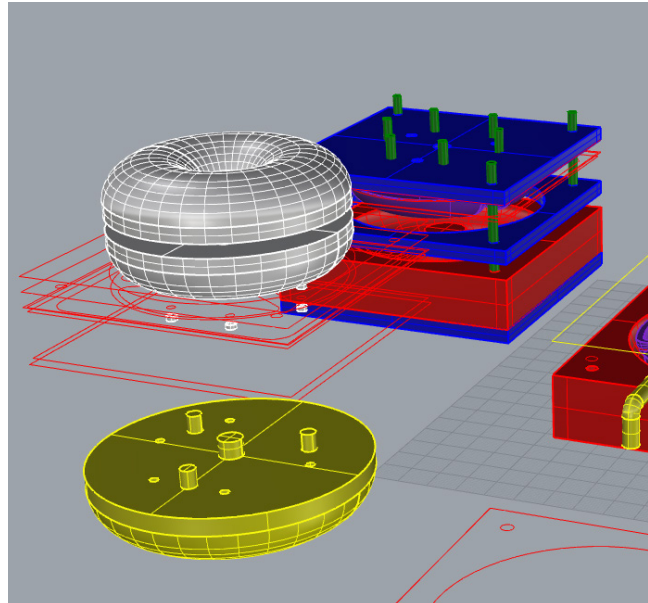
A symmetrical smooth donut form, with no obvious aesthetic link to any living thing. Stable and solid looking, the intention is to play on the contrast between a moulded (engineered) aesthetic and the strange, expressive behavioral movements of the uncanny soft robotic movements it will produce. Blo-nut was chosen to have three air chambers as to avoid comparison to symmetry in bodies, legs, hearts, lungs etc

P2 - Elasticity

No sharp edges lends to strength when inflated and ease of moulding and casting in latex or silicone.

P3 - Robustness

Small enough to be held in a shape that feels intuitive to pick up with no sharp edges that could be potential weak points in an elastic material.



CAD Modelling

The donut shape was modelled in RhinoCAD. The screenshots here shows early modelling of a half donut, inserts and a mould concept. See page 6, (REPEATABLE SILICONE MOULDING) for more details.

MATERIAL TESTING AND PROTOTYPING

P1- Juxtaposition

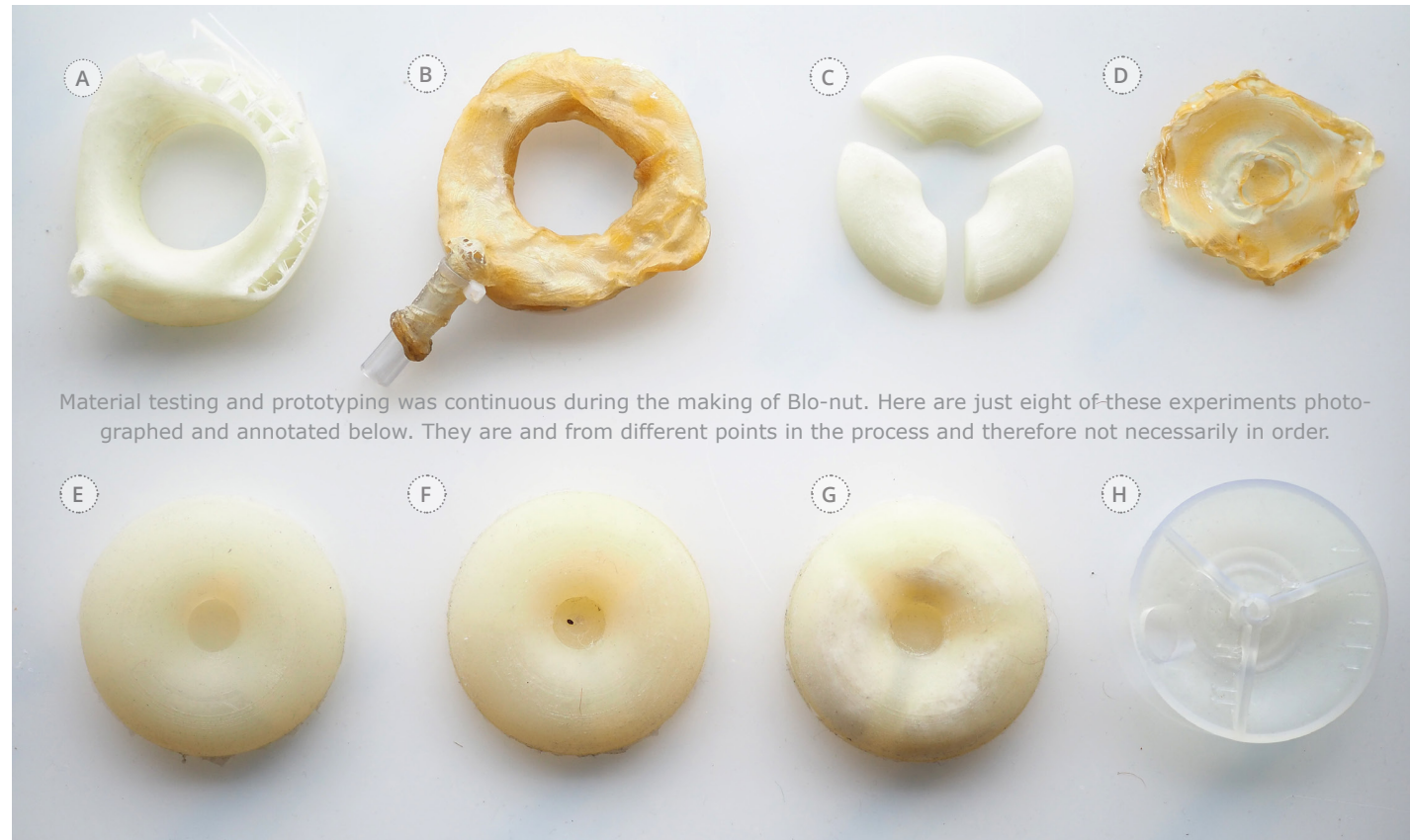
Material testing helped us understand our material and how we might juxtapose the flesh-like textures against the engineered shapes, fixtures and fittings of the final form.

P2 - Elasticity

We focused on liquid latex and silicone for their mouldable elastic and deformable qualities. The silicone we used is more elastic than the latex.

P3 - Robustness

Both latex and silicone have their advantages. Silicone in the way we worked with it is easier to get a uniform thickness. Liquid latex is easier to repair.



Material testing and prototyping was continuous during the making of Blo-nut. Here are just eight of these experiments photographed and annotated below. They are from different points in the process and therefore not necessarily in order.

- A/** Broken donut test form 3D printed in PVA. After moulding PVA can be dissolved out with water leaving an inflatable air chamber behind.
- B/** Six layers of liquid latex painted onto **A**. Very hard to remove once cured. Noted that the method leaves a finger print type effect from the 3D print layer texture.
- C/** Three separate and uniform segments printed in PVA. Ready for suspension in silicone mould, to be later dissolved out.
- D/** Four layers of liquid latex painted onto separate mould (not pictured) easier to remove and gives a delicate skin effect. Fails to meet the robustness principle.
- E/** First Donut cast test in silicone. Leaks from bubbles. Takes a long time to dissolve out PVA segments (**C**)
- F/** First non leaking silicone cast half donut. Tweaks to the inner segment 3D forms speed up dissolving process of PVA.
- G/** Partially dissolved inner segments still inside the silicone form gives a feeling of muscle and bone tissue underneath silicone skin.
- H/** SLA 3D printed base/ underside part allowed for mechanical assembly of half donut shape. More robust at this stage compared to original full donut intention.

REPEATABLE SILICONE MOULDING WITH SUSPENDED INSERTS

P1- Juxtaposition

The final shape feels solid with the inserts left inside. Movement is therefore not expected.

P2 - Elasticity

By suspending inserts inside a silicone mould it is possible to blow air between the two materials. This results in rapid and immediate inflation of the silicone.

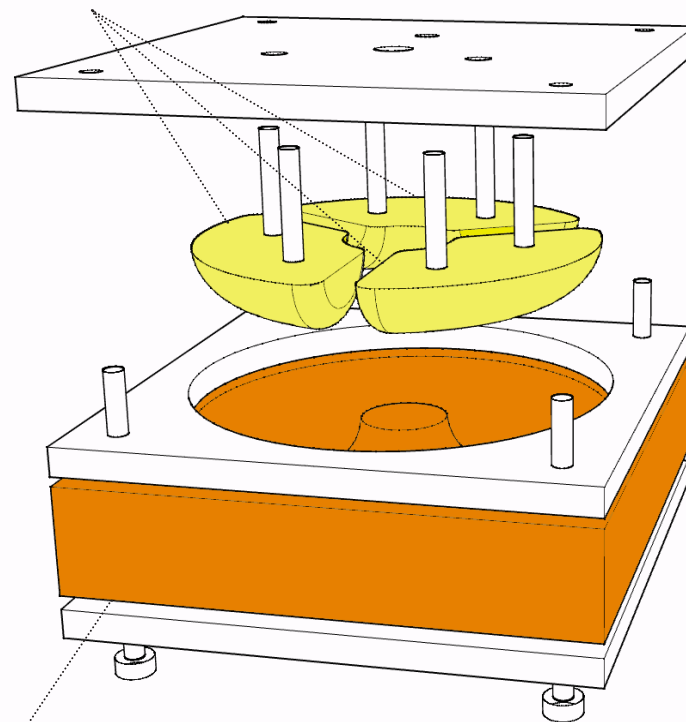
P3 - Robustness

With a mould we ensured repeatability and possibility to explore and iterate within these constraints. It also gave us the option to tweak the height of the inserts and therefore the thickness/strength of the silicone skin.

Mould - Exploded View

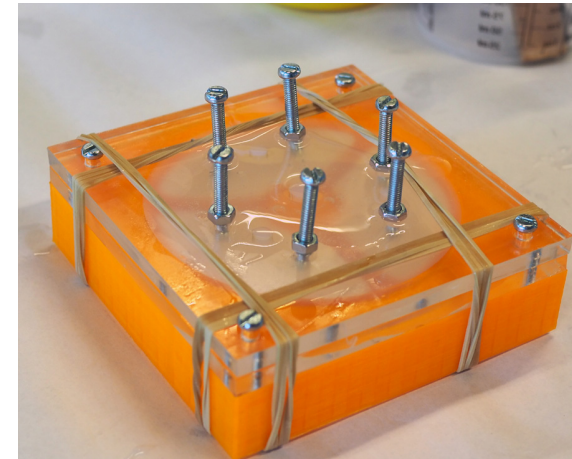
Inserts, suspended in mould (yellow),

These are left inside the final part, giving a sense of bone under skin



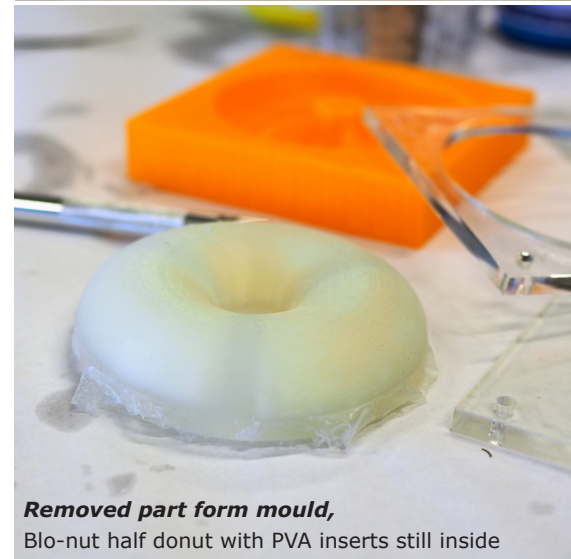
Outer shape Mould (orange)

3D Printed and defining the outer shape of the donut.



Moulding Silicone,

2-part Silicone (eco-flex) poured and held tight during curing phase



Removed part form mould,

Blo-nut half donut with PVA inserts still inside

**ASSEMBLING A
'FINISHED' PROTOTYPE****Moving Side**

(yellow/blue parts)

Expressive and moving.
Air Blown between yellow
part and blue parts

Rigid Underside

(pink parts)

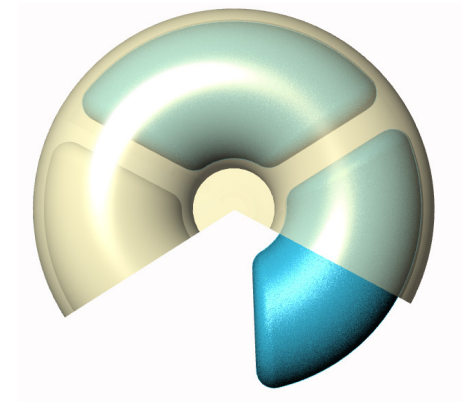
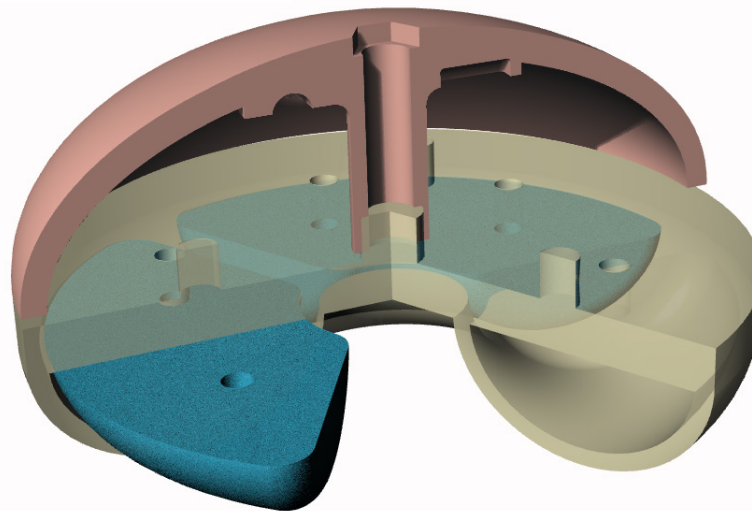
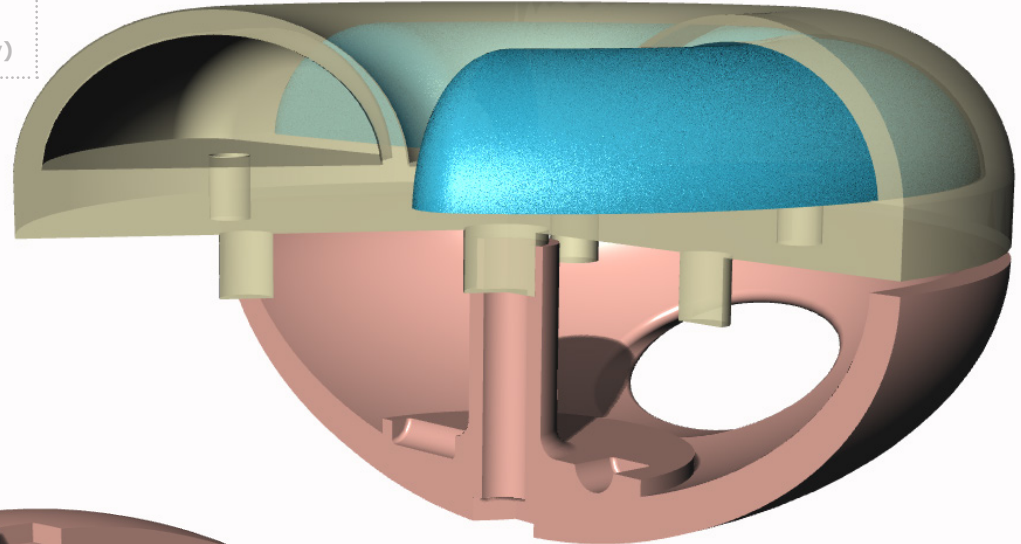
Containing lures,
connectors to protect
fragile parts. Containing
accelerometer, for future
interactivity testing.

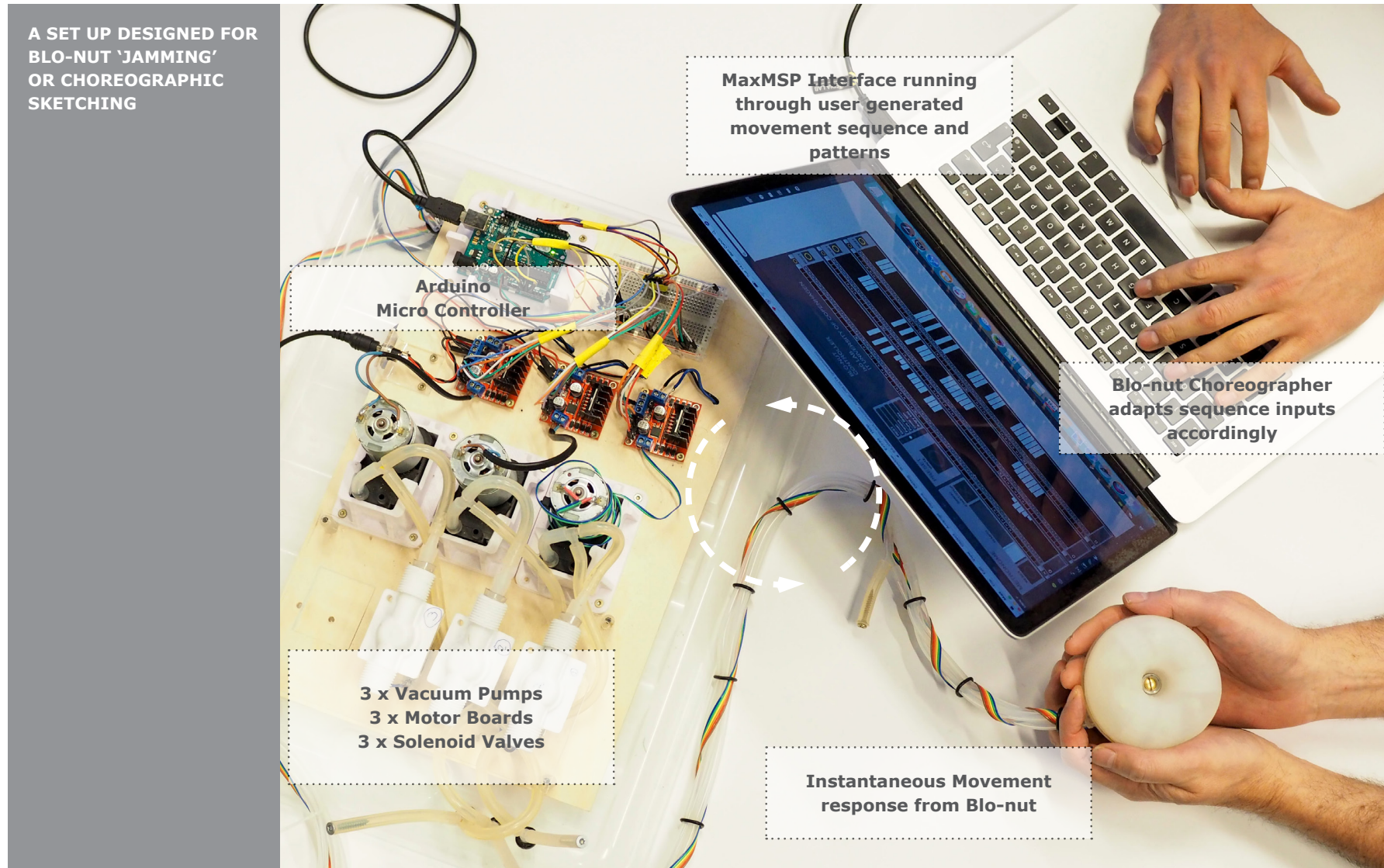
**Blo-nut Assembly (Partially
Assembled, Partially Cut Away)**

Pink Part,
3D printed Protective Shell

Yellow Part,
Moulded Silicone Skin

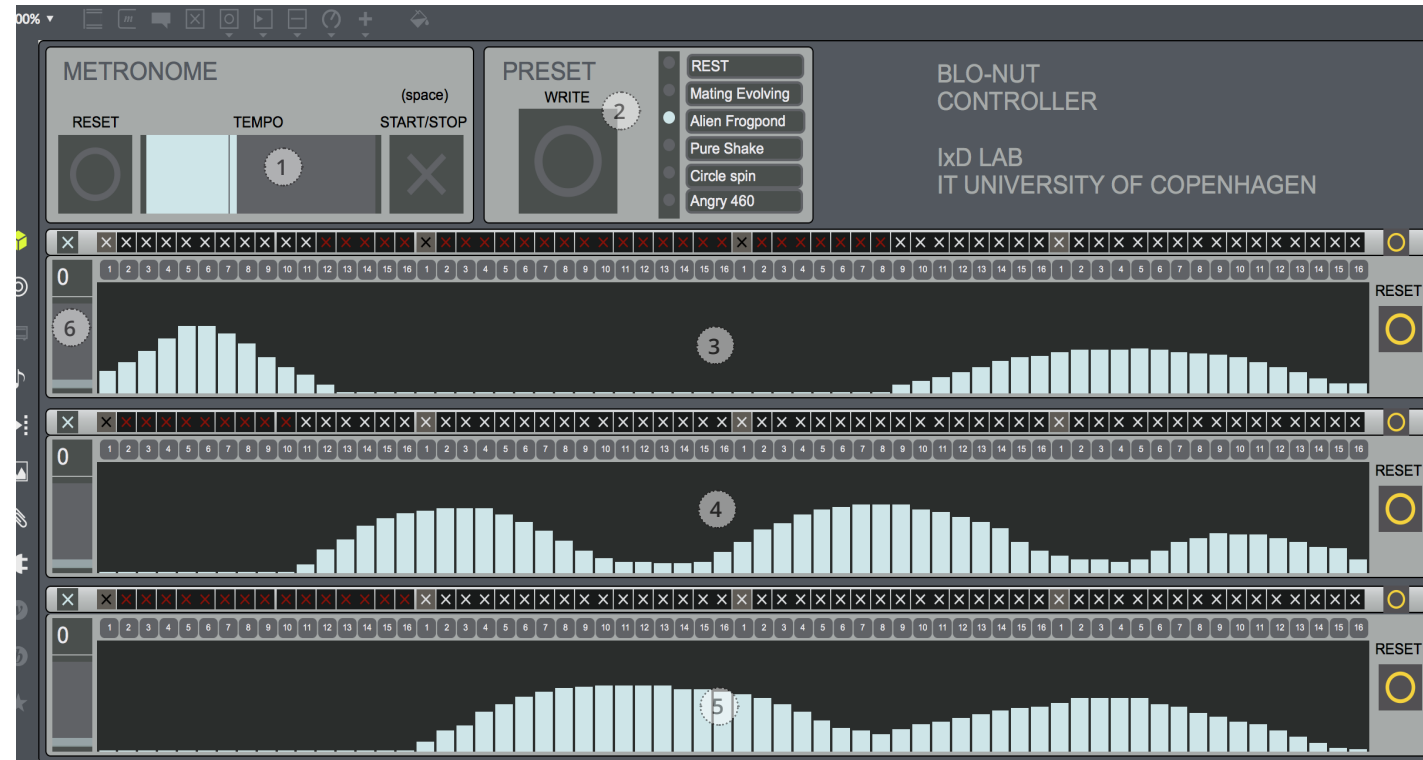
Blue Part,
3D Printed Inserts





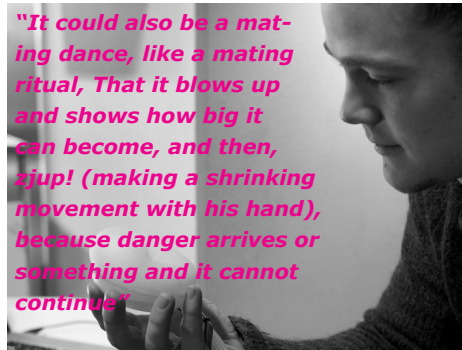
CHOREOGRAPHIC SKETCHING WITH MAX/MSP INTERFACE

- 1/
Set speed of tempo through sequence
- 2/
Save and Reset Sequences
- 3,4,5/
Individual sequences for each air chamber. Columns represent motor pump power at any given step
- 6/
Solenoid valve on/off at any given step. Allowing for nuances in rhythm, deflation and separation of motor noise from movement patterns.

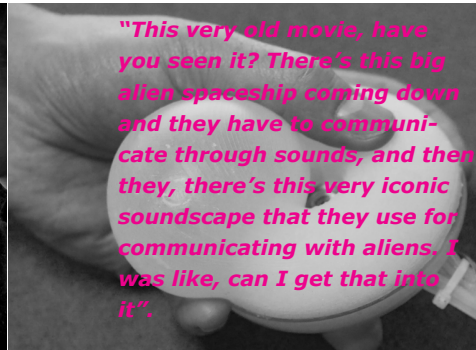


CHOROGRAPHER REACTIONS (RIGHT)

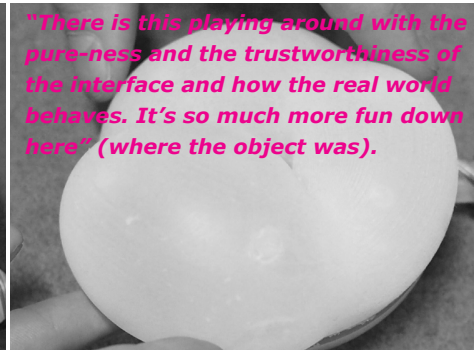
"It could also be a mating dance, like a mating ritual, That it blows up and shows how big it can become, and then, zup! (making a shrinking movement with his hand), because danger arrives or something and it cannot continue"



"This very old movie, have you seen it? There's this big alien spaceship coming down and they have to communicate through sounds, and then they, there's this very iconic soundscape that they use for communicating with aliens. I was like, can I get that into it".

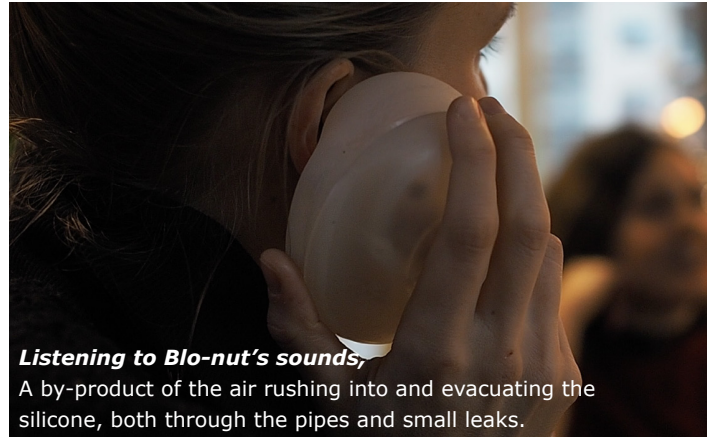


"There is this playing around with the pure-ness and the trustworthiness of the interface and how the real world behaves. It's so much more fun down here" (where the object was).



EXPERIENCING THE CHOREOGRAPHY

Blo-nut presented to a group of participants with Blo-nut contextualised in a speculative future scenario as a companion to replace pets.

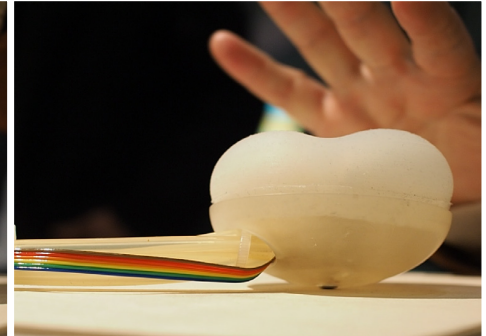
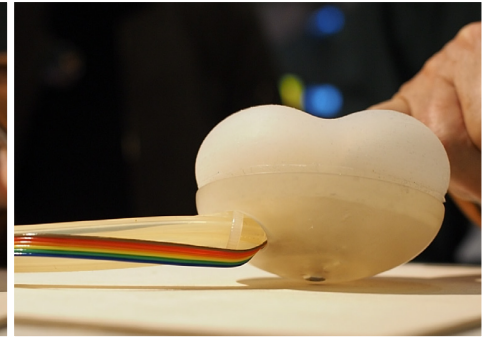
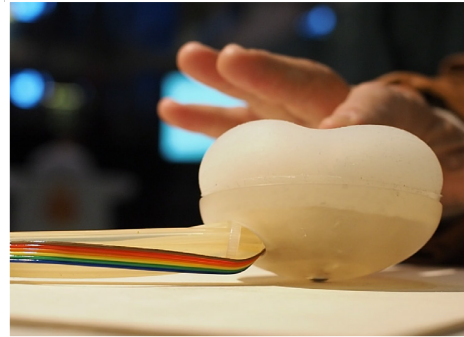


Listening to Blo-nut's sounds,

A by-product of the air rushing into and evacuating the silicone, both through the pipes and small leaks.



"...it's like you are touching the belly of a dog"



Other Forms

Methods presented in this pictorial adapted for a second prototype, Lat-Sac, a Blo-nut variant (Pictured right).

Lat-sac is also based roughly on a donut shape with three internal chambers inside a loose latex sack.

Presented alongside Blo-nut, This latex artefact provoked surprisingly different responses with its more 'finished' docking and less sterile latex texture.



Dock design details,

Connotations for perceived seriousness and reasons for Lat-sac's behavior.



How does it feel here?

A participant experimenting with the experience of putting their hand through Lat-sac .

Discussion.

The Blo-nut presented here has essentially provided us a tool to demonstrate and explore a rich variety of provoking behaviours possible with a transforming donut. Our choreographic sketching set up has also drawn attention to the benefits of inviting those with specialist knowledge in expressive movement in to the design process, especially if we are to broaden temporal form opportunities. Furthermore in presenting Blo-nut to an audience as an interactive object, we have demonstrated how these expressions and behaviours can trigger interpretive responses that are as imaginative as they are diverse. It is clear that a design strategy liberated from obvious mimicry of human and animal movements can produce provocative and novel interactive experiences. Undoubtedly, Blo-nut and the lesser described Lat-sac (left) merely scratch the surface of possible experiences with otherness objects. We suggest that with further refinement of the design principles and continued creation of new 'otherness' social robots we can begin to understand emerging patterns of interaction, potential new applications and social impact of these emotive technologies. Finally, we suggest that by making more of these objects we can begin to describe social robots with a much expanded vocabulary for novel and provoking robotic movement.

Acknowledgements

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